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Acoustic remote sensing of LPBL over Antarctic environment

N C Deb*
Electronics & Communication Sciences Unit, Indian Statistical Institute, 203, B T Road, Kolkata-700 035, India
E-mail : narayan@isical ac in
and
Swati Chowdhury
Machine Intelligence Unit, Indian Statistical Institute, 203, B T Road, Kolkata-700 035, India
and
Amita Pal
Applied Statistics Unit, Indian Statistical Institute, 203, B T Road, Kolkata-700 035, India

Abstract Acoustic sounding experiment and meteorological observations were carried out on simultaneous basis at the Indian Antarctic station Maitri (70 76°S, 11 73°E) during XV-th Indian Scientific Expedition to Antarctica from January 1995 to January 1997. The entire Antarctic zone is very prone to the sudden occurrence of blizzards during different month and seasons This stormy activity brings drastic changes in the planetary boundary layer over Antarctica. In order to understand the dynamics of LPBL over this region, all meteorological parameter before onset of blizzard, during and after blizzard have been studied Impact of these blizzards on sodar structures is also highlighted. The effect of various other phenomena such as katabatic wind, forced convection, *etc.* are also visualized.

Keywords LPBL, acoustic sounder, Antarctic environment

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1. Introduction

The Antarctic continent comprises one tenth of the land surface of the earth and the Antarctic seas makes up about one tenth of the world's oceans. This huge continent is covered with a permanent sheet of ice. It is considered to be a major heatsink which plays a vital role in maintaining the balance of heat energy and momentum of entire earth's environment. Scientists from different corners of the globe have realized the fact and started exploring the Antarctic environment since 1956. We have also planned to investigate the characteristics of LPBL (Lower Planetary Boundary Layer) over Antarctica. We have installed a monostatic sodar system and recorded the observations on a regular basis. We have collected meteorological data using different *in situ* measurement techniques. The entire Antarctic zone is very prone to the occurrence of blizzards throughout the year. In this paper we will present the different type of sodar structures observed over Antarctica during the course of data collection. Meteorological observations are recorded carefully during and after departure of blizzard. In addition to this, we will discuss about the discrepencies in the behavior of the meteorological parameters observed during the normal and stormy period over Antarctica.

2. Description of the system and data collection

Figure 1 shows the block diagram of a monostatic acoustic sounding system, working successfully at Maitri, Antarctica.

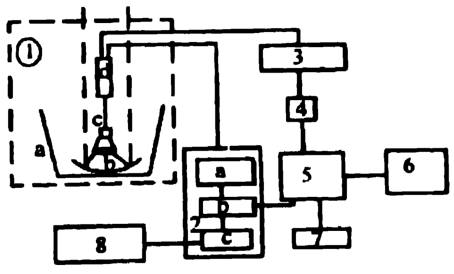


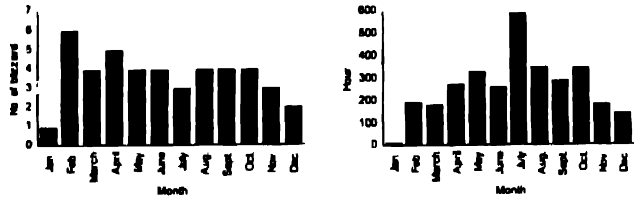
Figure 1. Block diagram of sodar system : (1) Antenna system : (a) acoustic shield, (b) parabolic dish made of fiber glass, (c) transducer with cone, (d) transmit receive switch with pre-amplifier. (2) Receiving unit : (a) band pass filter, (b) detector, (c) log amplifier. (3) Power amplifier (4) Low pass filter (5) Personal computer. (6) Vedio display unit. (7) Digital printer. (8) Facsimili recorder.

* Corresponding Author

A trans-receiving antenna has been used to transmit and receive the sound signal (50 milisecond pulse of 1800 Hz tone) and the system is fully computer-controlled. This is a monostatic acoustic sounder and emits high power acoustic pulses with a single parabolic antenna. The same antenna performs as the receiver of the backscattered signals. The system emits sound pulses of 1800 Hz, each of 50 millisecond duration, at intervals of 10 seconds. The scattered intensity of acoustic pulses reflected by scatterer (temperature inhomogenities) at different heights are measured at an interval of 2 meters vertical distance upto 1 kilometer. Digitized data, are stored in computer memory and online display of the atmospheric structure can also be observed on computer screen. At the same time, the three dimensional (time, height and intensity) behaviour of the analog signals also are recorded on facsimili chart recorder. Attempt has been made to record the data on a round-the-clock basis during the normal days (wind is less than 10 knots).

3. Observations and analysis

Figures 2a and 2b are drawn to get further knowledge of blizzard history over Antarctica. Figure 2a presents the



(a) (b)

Figure 2. (a) Total number of blizzard per month and (b) Total duration of blizzard per month

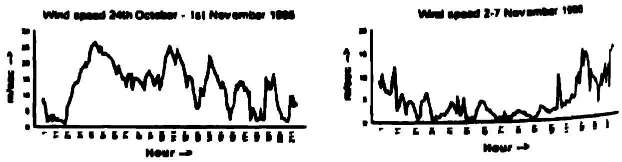
monthly variation in number of blizzards. Similarly, Figure 2b shows the monthly variation in duration of blizzards during different months. Figure 2a shows that maximum number of blizzards occur during the month of February whereas it is minimum in January. On the other hand, Figure 2b shows that total duration of blizzard is maximum in July and minimum in January.

Table 1 shows the date and time of onset, offset and duration of blizzards observed at Maitri (Antarctica) during the year 1996. The minimum duration (10 hours) of blizzard were observed on 20th February 1996. Whereas maximum duration (347 hours) of blizzard were observed during 15th July to 30th July 1996 respectively. It can be observed from this table that a total of 38 blizzards occurred at our site of experiment during that year. Maximum wind gust (62 m/s) was recorded on 18th July 1996.

Figures 3a and 3b show the variation in wind speed during the blizzard days and normal days respectively. During the blizzard days, wind speed is comparatively much higher (as high as 25 m/sec) than that on normal days (5 to 10 m/sec).

Table 1. Blizzard observed at Maitri (Antarctica) during the year 1996.

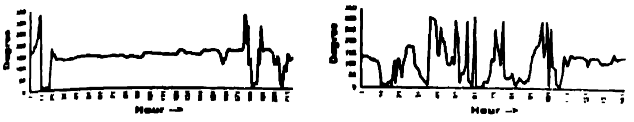
	Onset of blizzard		Offset of blizzard		Duration of blizzard	
No	Date	Time	Date	Time	Hour	Minute
1	31.01.1996	08:45	02.02 1996	09:50	49	05
2	06.02 1996	00·00	08 02.1996	03:50	51	50
3	11.02.1996	23:30	14 02 1996	07:30	56	00
4	20 02.1996	00:00	20.02.1996	10.00	10	00
5	23 02.1996	03:00	24.02.1996	09:00	30	00
6	25 02.1996	01.00	25.02.1996	13.00	12	00
7	02 03.1996	17 00	05 03 1996	07:25	62	25
8	21.03.1996	01 40	21 03.1996	18:55	13	15
9	24.03.1996	05 45	27 03 1996	13·20	79	35
10	30 03.1996	17 50	02.04.1996	07.15	37	25
11	04.04 1996	23:25	07.04.1996	02:40	51	15
12	10 04 1996	19:50	11 04.1996	17:20	21	30
13	14.04.1996	00.00	16.04.1996	16:55	64	55
14	17 04 1996	10.35	21 04.1996	22.20	107	45
15	01 05.1996	11.15	05.05 1996	13.10	97	55
16	08 05 1996	08 45	09 05 1996	03.35	18	50
17	15 05.1996	00 00	17.05.1996	03.25	51	25
18	25.05 1996	02·25	01 06.1996	19.40	185	15
19	04.06.1996	19·35	05 06 1996	14:55	19	20
20	08.06.1996	06·25	15.06.1996	04 15	165	50
21	28 06.1996	11.35	08 07.1996	16 20	240	45
22	11 07 1996	01:40	13 07 1996	10.15	56	35
23	15.07 1996	23 25	30.07 1996	10 30	347	05
24	03 08 1996	07.55	06 08 1996	18 45	82	50
25	09 08.1996	14 40	10 08.1996	15.35	24	55
26	17 08 1996	09.50	19.08 1996	03 35	41	45
27	23 08 1996	15 00	01.09.1996	12·00	213	00
28	13.09.1996	00.00	14.09.1996	11:25	35	25
29	16.09 1996	16:45	23 09.1996	07:10	158	25
30	26 09 1996	20:20	30 09.1996	08:25	84	05
31	02.10.1996	21.10	05.10.1996	19:25	70	15
32	15.10.1996	02:25	18 10.1996	12:30	82	05
33	21.10.1996	21:20	23.10.1996	04:55	31	35
34	25.10.1996	04:15	01 11 1996	06:50	170	35
35	07.11.1996	22:00	12.11.1996	13:55	111	55
36	21.11.1996	11:50	24 11.1996	06:35	66	45
37	01.12.1996	00:00	02.12.1996	07:15	31	15
38	15.12.1996	00:00	19.12.1996	15:15	111	15



(a) (b)

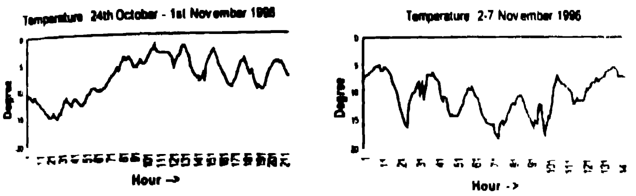
Figure 3. (a) Blizzard days and (b) normal days.

Figures 4a and 4b depict the direction of wind during the blizzard and normal days respectively. It can be observed



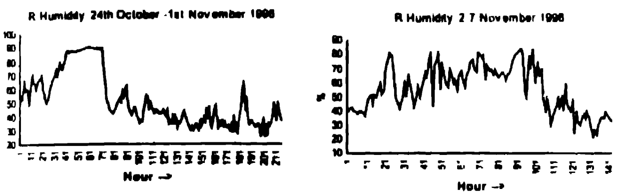
(a) (b)

Figure 4. (a) Blizzard days and (b) normal days



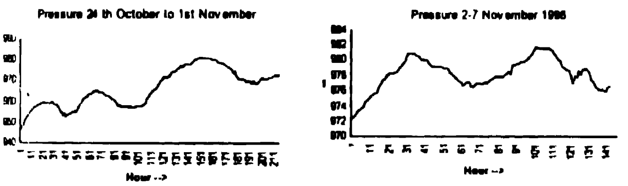
(a) (b)

Figure 5. (a) Blizzard days and (b) normal days



(a) (b)

Figure 6. (a) Blizzard days and (b) normal days.



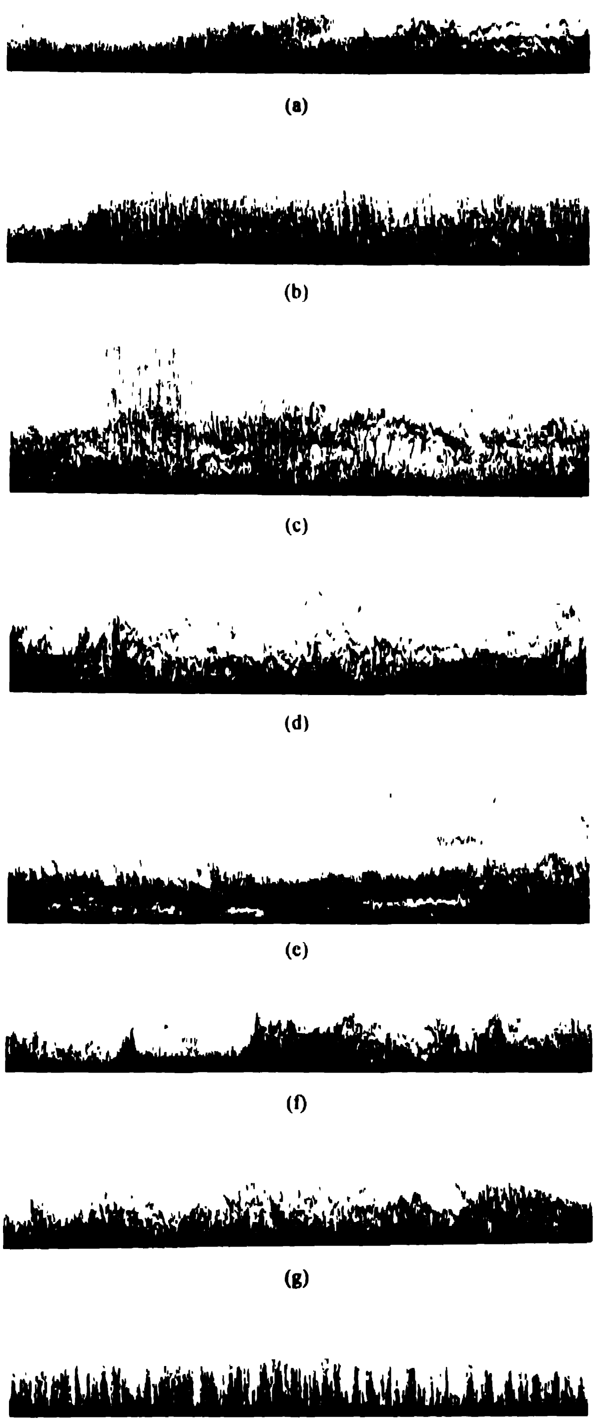
(a) (b)

Figure 7. (a) Blizzard days and (b) normal days

that during the blizzard days, wind direction remained constant at 150° whereas on normal days, it varied between 0° to 300°.

4. Conclusion and application

Experimental observations on Antarctica show that for more than one third of a year, this area remains under the influence of stormy activity which in turn, brings drastic changes in the characteristics of lower planetary boundary layer. Sodar observations reveal that the mechanical turbulence introduced in LPBL due to stormy activities and frontal disturbances (generated from the Antarctic ocean) affects the uniform formation of ground based inversion layers significantly. In addition to this, formation of multilayered structures at the elevated level are also absent during this period. On the other hand, during the normal days a thick (about 500 m) ground based inversion layer with uniform top is formed and sometimes it is associated with multilayered structures appearing in the at 700 to 1000 m range. A noticeable



(a)

(b)

(c)

(d)

(e)

(f)

(g)

(h)

Figure 8. (a) May 5, time · 0050 to 0850 hours, (b) May 21, time : 1020 to 1820 hours; (c) May 12, time · 0720 to 1520 hours; (d) May 22, time: 1900 to 0300 hours; (e) August 22, time : 1030 to 1830 hours, (f) September 25, time : 1610 to 0010 hours; (g) November 17, time : 1015 to 1815 hours and (h) December 6, time : 0910 to 1710 hours

difference has also been observed in the behaviour of various meteorological parameters recorded during the stormy and normal periods. These discrepancies can be used to develop an appropriate mathematical model for the Antarctic environment. At the same time this type of study can prove extremely useful in determining the merits and demerits of radio communication and other related fields.

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